CLAIMS:

1. A photomask blank comprising a substrate and a multilayer film thereon including at least four layers of different compositions, wherein the interface between the layers is moderately graded in composition.

2. The photomask blank of claim 1 wherein said multilayer film includes layers composed mainly of compounds of metal silicide with oxygen and/or nitrogen.

3. The photomask blank of claim 1 wherein said multilayer film includes at least one layer composed mainly of molybdenum silicide oxynitride.

4. The photomask blank of claim 1 wherein said multilayer film is a phase shift film, said blank further comprising a chromium base light-shielding film or a chromium base antireflection film or a laminate film having stacked at least one chromium base light-shielding film and at least one chromium base antireflection film, formed on said multilayer film.

5. A method for manufacturing the photomask blank of claim 1, comprising

sputter-depositing layers on the substrate using a sputtering deposition system equipped with a plurality of targets of different compositions, across which electric powers are applied for sputtering, and

gradually changing a combination of sputtering powers across the targets in proximity to the interface between layers, thereby depositing a plurality of layers of different compositions.

6. The method of claim 5 wherein the plurality of targets comprise a metal silicide target and a silicon target.

7. The method of claim 5 wherein the plurality of targets comprise a metal target and a silicon target.

8. The method of claim 5 wherein the step of gradually changing a combination of sputtering powers across the targets in proximity to the interface between layers continues for a power grading time period which is at least 10% of a time period required to complete deposition of each layer.

9. A photomask fabricated by patterning the multilayer film of the photomask blank of claim 1.

10. A phase shift mask blank comprising a transparent substrate and a phase shift film of at least two layers thereon,

said phase shift film having a composition based on a zirconium silicide compound on a surface side and a composition based on a molybdenum silicide compound on a substrate side,

said phase shift film including a first layer, a second adjacent layer of a different composition, and a third layer disposed between the first and second layers and having a composition moderately graded from the composition of the first layer to the composition of the second layer.

11. The phase shift mask blank of claim 10 wherein an intermediate layer is disposed between a surface layer of a composition based on a zirconium silicide compound and a substrate-adjacent layer of a composition based on a molybdenum silicide compound, said intermediate layer having a composition moderately graded from the composition of the surface layer to the composition of the substrate-adjacent layer.

12. The phase shift mask blank of claim 10 wherein a surface layer of a composition based on a zirconium silicide compound is a coating composed mainly of a compound of zirconium silicide with oxygen and/or nitrogen and a substrate-adjacent layer of a composition based on a molybdenum silicide compound is a coating composed mainly of a compound of molybdenum silicide with oxygen and/or nitrogen.

13. The phase shift mask blank of claim 10, further comprising a chromium base light-shielding film or a chromium base antireflection film or a laminate film having stacked at least one chromium base light-shielding film and at least one chromium base antireflection film, formed on said phase shift film.

14. A method for manufacturing the phase shift mask blank of claim 10, comprising

sputter-depositing layers on the substrate by using a sputtering deposition system comprising a molybdenum silicide target, a zirconium silicide target and optionally a silicon target in a chamber, feeding a sputtering gas containing at least oxygen and/or nitrogen, and applying electric powers across the targets for sputtering, and

changing a combination of sputtering powers across the targets, thereby forming the phase shift film having a graded composition.

15. A phase shift mask fabricated by patterning the phase shift film of the phase shift mask blank of claim 10.

16. A phase shift mask blank comprising a substrate which is transparent to exposure light and a phase shift film thereon, said phase shift film having one side contacting the substrate and a surface side remote therefrom,

said phase shift film comprising a plurality of layers containing a metal and silicon in different compositional ratios which are stacked in such order that a layer having a higher etching rate is on the substrate side and a layer having a lower etching rate is on the surface side.

17. The phase shift mask blank of claim 16 wherein said phase shift film comprises one of metal silicide oxide, metal silicide nitride, metal silicide oxynitride, metal silicide oxycarbide, metal silicide nitride carbide and metal silicide oxide nitride carbide.

18. The phase shift mask blank of claim 16 wherein said metal is molybdenum.

19. The phase shift mask blank of claim 18 wherein in said phase shift film, the plurality of layers are stacked such that the compositional ratio of silicon to molybdenum increases from the substrate side to the surface side.

20. The phase shift mask blank of claim 16 wherein a phase difference distribution in a substrate plane at the wavelength of light used for exposure has a center value of 180±10 degrees, and a transmittance distribution in a substrate plane has a center value of 3 to 40%.

21. The phase shift mask blank of claim 20 wherein the phase difference distribution in a substrate plane at the wavelength of light used for exposure is within ±2.0 degrees relative to its center value, and the transmittance distribution in a substrate plane is within ±0.15% relative to its center value.

22. A method for manufacturing the phase shift mask blank of claim 16, comprising

using a sputtering system capable of simultaneously causing at least two targets to produce electric discharges, and

sputtering a combination of at least two metal silicide targets, or a combination of at least one metal silicide target with a metal target or a silicon target or both, thereby depositing layers on the substrate to form the phase shift film.

23. The method of claim 22 wherein the sputtering is reactive sputtering using a reactive gas, and

said phase shift film comprises one of metal silicide oxide, metal silicide nitride, metal silicide oxynitride, metal silicide oxycarbide, metal silicide nitride carbide and metal silicide oxide nitride carbide.

24. The method of claim 22 wherein said metal is molybdenum.

25. The method of claim 24 wherein in said phase shift film, the plurality of layers are stacked such that the compositional ratio of silicon to molybdenum increases from the substrate side to the surface side.

26. A phase shift mask fabricated by patterning the phase shift film of the phase shift mask blank of claim 16.

27. A method for manufacturing a phase shift mask, comprising

forming a resist film pattern on the phase shift film of the phase shift mask blank of claim 16 by lithography,

etching away those portions of the phase shift film which are not covered with the resist film, and

removing the resist film.